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#19 Appeal Brief
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PATENT

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE
BEFORE THE BOARD OF PATENT APPEALS AND INTERFERENCES

Applicant :	Raymond J. Beach et al.	Attorney Docket: IL-10571
Serial No. :	09/651,658	Art Unit: 2828
Filed :	August 29, 2000	Examiner: C. Jackson
For :	Tapered Laser Rods As A Means Of Minimizing The Path Length Of Trapped Barrel Mode Rays	

BRIEF ON APPEAL

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This is an appeal to the Board of Patent Appeals and Interferences from the final rejection of Claims 1-20 mailed January 15, 2003. On May 15, 2003, a timely Notice of Appeal was filed.

I. REAL PARTIES IN INTEREST

The real parties in interest are the Regents of the University of California and the United States of America as represented by the United States Department of Energy.

II. RELATED APPEALS AND INTERFERENCES

Appellant knows of no other appeals or interferences that will directly affect or be directly affected by or have a bearing on the Board's decision in the pending appeal.

III. STATUS OF CLAIMS

Claims 1-20 are pending on appeal and stand rejected. A copy of the claims on appeal are set forth in Appendix I.

IV. STATUS OF AMENDMENTS

All prior amendments have been entered. An amendment and declaration are filed herewith. The amendment should be entered because it removes an issue, i.e., it clarifies that the applicants' laser rod is uncoated. This removes the Peressini reference.

V. SUMMARY OF INVENTION

The invention to provides a technique for reducing the ability of the trapped spontaneous emission to negatively impact laser performance through amplified spontaneous emission (ASE). A tapered laser rod having flanged endcaps dramatically reduces the maximum trapped path length of barrel modes within the laser rod.

A flanged endcap effectively traps the swirling ASE rays, causing them to be scattered out of the laser rod. However, limiting the trapped ray paths to one pass down the length of the laser rod can still allow for very long ray paths to be trapped, causing gain depletion in the laser rod. The present invention limits the maximum ray paths that can be trapped within the laser rod by tapering the laser rod over its length. This tapered design combined with flanged endcaps eliminates deleteriously long trapped path lengths.

Tapering the diameter of the laser rod over its length thus reduces the maximum trapped path length of barrel modes, reducing the ability of the trapped spontaneous emission to negatively impact laser performance through amplified spontaneous emission. In the present invention, a laser rod incorporates both undoped flanged endcaps and a tapered barrel.

In one embodiment, the rod barrel tapers in diameter from a small value of at one end to a larger value at the other end. By introducing a taper on the barrel of the laser rod, swirling rays are prevented from loitering for extended path lengths in the

laser rod. This is a significant improvement over the use of the flanged endcaps on a straight barreled rod, as the straight barrel rod configuration still allows trapped paths with infinite length.

Due to the rod's taper, there is a portion of the laser rod's volume that will be inaccessible to an extracting laser beam due to the aperture introduced by the small end of the laser rod. Because this inaccessible volume grows as the taper grows, there will be an optimum taper value.

In another embodiment, the center of the laser rod is the narrowest and the diameter increases towards either end. The advantage of this geometry, with its dual taper, over a rod with a continuous taper from one end to the other, is that the maximum trapped path length in this rod is halved compared to that in the continuously tapered rod.

VI. ISSUES

Whether claims 1-3, 5-8, 11-18 and 20 are unpatentable over Meissner et al. (5936984) in view of Peressini (6418156).

Whether claims 4, 9, 10 and 19 are unpatentable over Meissner et al. (5936984) and Peressini (6418156) as applied to claims 1-3, 5-8, 11-18 and 20 above, and further in view of Tang (6263007).

VII. GROUPING OF CLAIMS

Claims 2-5, 8-11, 13-15 and 17-19 stand or fall together. Claims 6, 12, 16 and 20 are separately patentable from each other and from claim 1. Claims 7 and 11 stand or fall together, but are separately patentable from all other claims.

VIII. ARGUMENT

Are claims 1-3, 5-8, 11-18 and 20 unpatentable over Meissner et al. (5936984) in view of Peressini (6418156)?

As discussed in the attached declaration, which is fully incorporated herein, Meissner et al. (US 5,936,984), of which the declarant is a co-inventor, discloses a laser rod design with a polished barrel; however, the reference only has a taper or flange on the undoped portion of the laser rod near the laser rod's two ends, while the applicants' invention explicitly claims a taper over the entire doped length of the laser rod.

The Peressini patent (US 6,418,156 B1) shows a laser rod tapered along its length (Fig. 11); however, this is not related to parasitic suppression, which is the reason the applicants' laser rods are tapered. Peressini places a taper on the various laser gain elements to maximize the path length of the pump rays within the gain medium, which can be advantageous for some specific classes of laser as it permits lower doping densities of lasant ions to be effectively utilized. There are two major differences between the structures claimed by Peressini and those claimed by the applicants:

1. The structures in the Peressinipatent are all constructed so that the pump radiation is introduced into the gain medium in a direction transverse to the laser axis,

whereas the applicants' tapered laser rods are all constructed so that the pump radiation is introduced substantially parallel to the laser axis.

2. The structures in Perisini control ASE and parasitics through the use of special optical coatings on the transverse sides of their gain elements. Throughout the discussion in the Peressinipatent it is emphasized that the purpose of the coatings is two fold. The coatings are intended to either absorb or efficiently out couple ASE from the laser gain media, as well as confine the pump radiation to the laser rod via high efficiency reflection. See column 17, lines 18-24. However, the applicants' laser rods are specifically uncoated on their transverse side; they efficiently transport ASE from the laser rod where it develops to the ends of the laser rod where the ASE is quenched in the endcaps. See, e.g., page 2, lines 9-11. Claims 1, 12 and 16 have been amended to clarify that the laser rods are uncoated. Therefore the rejection should be withdrawn.

<u>Are claims 4, 9, 10 and 19 unpatentable over Meissner et al. (5936984) and Peressini (6418156) as applied to claims 1-3, 5-8, 11-18 and 20 above, and further in view of Tang (6263007)?</u>

The rejection should be withdrawn because claims 4, 9 and 10 depend from independent claim 1 and claim 19 depends from independent claim 16. Claims 1 and 16 should be allowable as discussed above.

Further, Tang (US 6,263,007 B1) contains a diagram showing a tapered gain volume (Fig. 9), but this is unrelated to the applicants' tapered laser rod. The most important difference between the tapered gain volume in Tang and the applicants'

tapered laser rod is that the tapered region in Tang is a low refractive index region (near unity, containing a gaseous medium), while the surrounding medium does not even have to be optically transparent at the laser wavelength. In the applicants' tapered laser rod, the rod itself has to have higher refractive index than the surrounding medium, and the surrounding medium (typically cooling water or air) is also required to be optically transparent at both the pump and the laser wavelengths. The reason for the tapers in the Tang patent are to pinch down the optical cavity so as to only permit lasing to occur in the fundamental (or $TEM_{0,0}$) mode – a technique known as spatial filtering in the laser scientific and technical literature. There is no connection between ASE and parasitic management and the use of tapered laser regions in the Tang patent.

Therefore the rejection should be withdrawn.

Why the appellant Believes Claims 1, 6, 7, 11, 12, 16 and 20 Are Separately Patentable.

Claim 1 is separately patentable from claims 12 and 16 because this claim included at least the polished uncoated doped laser rod, which is absent from any of the cited references, without the limitations of claim 12 of the cooling jacket and lens duct, and is not a method claim such as claim 16.

Claim 6 is separately patentable because the cited references do not disclose, nor does any other claim of the present application recite, a rod that tapers in diameter from a small value of d at one end to a larger value of $d+\varepsilon$ at the other end.

Claims 7 and 11 are separately patentable from all other claims, but stand or fall together because the cited references do not disclose, nor does any other claim of the present application recite, a laser rod having a tapered diameter that is optimized to a taper value that balances the contradictory requirements of maximizing the size of said taper so as to minimize the longest trapped path length of light rays propagating within said laser rod, and minimizing the size of said taper so as to maximize the fractional volume in said laser rod that is accessible to an extracting laser beam.

Claim 12 is separately patentable from claims 1 and 16 because it defines a complete solid state laser and includes a cooling jacket sealably coupled to said first and second flanged end-caps; a pump laser for providing pump laser light directed at said first flanged end-cap; and a lens duct interposed between said pump laser and said first flanged end-cap, wherein said lens duct will concentrate said pump laser light.

Claim 16 is separately patentable from claims 1 and 12 because it provides a method for fabricating a laser rod.

Claim 20 is separately patentable from all other claims because it provide a method for optimizing the diameter of said laser rod to a taper value that balances the contradictory requirements of maximizing the size of said taper so as to minimize the longest trapped path length of light rays propagating within said laser rod, and minimizing the size of said taper so as to maximize the fractional volume in said laser rod that is accessible to an extracting laser beam.

Accordingly it is submitted that the rejections of Claims 1-20 under 35 U.S.C. § 103(a) are improper and should be reversed.

Respectfully submitted,

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IX APPENDIX I

1. An apparatus, comprising:

a polished uncoated doped laser rod comprising a first end and a second end and an entire length, wherein said laser rod comprises a tapered diameter along said entire length;

a first flanged endcap operatively connected to said first end; and

a second flanged endcap operatively connected to said second end.

2. The apparatus of claim 1, wherein said laser rod comprises a maximum diameter at said first end and a minimum diameter at said second end.

3. The apparatus of claim 1, wherein said laser rod comprises a maximum diameter at said second end and a minimum diameter at said first end.

4. The apparatus of claim 1, wherein said laser rod comprises a minimum diameter at about half the distance from said first end to said second end.

5. The apparatus of claim 1, wherein said first flanged endcap and said second flanged endcap are undoped.

6. The apparatus of claim 1, wherein said laser rod tapers in diameter from a small value of d at one end to a larger value of d+ε at the other end.

7. The apparatus of claim 1, wherein said tapered diameter is optimized to a taper value that balances the contradictory requirements of maximizing the size of said taper so as to minimize the longest trapped path length of light rays propagating within said laser rod, and minimizing the size of said taper so as to maximize the fractional volume in said laser rod that is accessible to an extracting laser beam.

8. The apparatus of claim 1, wherein said tapered diameter continuously continuous changes over the entire length of said laser rod.

9. The apparatus of claim 1, wherein said laser rod is narrowest between the ends of said laser rod and the diameter increases at each end.

10. The apparatus of claim 1, wherein said laser rod is narrowest at about half the distance between the ends of said laser rod and the diameter increases as you go towards either end.

11. The apparatus of claim 10, wherein said tapered diameter is optimized to a taper value that balances the contradictory requirements of maximizing the size of said taper so as to minimize the longest trapped path length of light rays propagating within said laser rod, and minimizing the size of said taper so as to maximize the fractional volume in said laser rod that is accessible to an extracting laser beam.

12. A solid state laser, comprising:

a uncoated doped laser rod with a first end and a second end and an entire length, wherein said laser rod comprises a tapered diameter along said entire length;

a first flanged, undoped end-cap optically contacted to said first end portion to form a first interface;

a second flanged, undoped end-cap optically contacted to said second end to form a second interface;

a cooling jacket sealably coupled to said first and second flanged end-caps;

a pump laser for providing pump laser light directed at said first flanged end-cap; and

a lens duct interposed between said pump laser and said first flanged end-cap, wherein said lens duct will concentrate said pump laser light.

13. The solid state laser of claim 12, wherein said laser rod has a host lattice, and wherein said host lattice and said first and second flanged end-caps are selected from the group consisting of yttrium aluminum garnet, gadolinium gallium garnet, gadolinium scandium gallium garnet, lithium yttrium fluoride, yttrium vanadate, phosphate glass and sapphire.

14. The solid state laser of claim 13, wherein said host lattice is doped with a material selected from the group consisting of Ti, Cu, Co, Ni, Cr, Ce, Pr, Nd, Sm, Eu, Gd, Tb, Dy, Ho, Er, Tm and Yb.

15. The solid state laser of claim 12, wherein said laser rod comprises Yb.sup.3+ doped YAG, and wherein said pump laser is an InGaAs diode laser array.

16. A method for fabricating a laser rod, comprising:

providing a polished uncoated doped laser rod comprising a first end and a second end and an entire length;

operatively connecting a first flanged endcap to said first end;

operatively connecting a second flanged endcap to said second end; and

tapering the diameter of said laser rod along said entire length.

17. The method of claim 16, wherein the step of tapering the diameter of said laser rod comprises forming a maximum diameter at said first end and a minimum diameter at said second end.

18. The method of claim 16, wherein the step of tapering the diameter of said laser rod comprises forming a maximum diameter at said second end and a minimum diameter at said first end.

19. The method of claim 16, the step of tapering the diameter of said laser rod comprises forming a minimum diameter at about half the distance from said first end to said second end.

20. The method of claim 16, further comprising optimizing the diameter of said laser rod to a taper value that balances the contradictory requirements of maximizing the size of said taper so as to minimize the longest trapped path length of light rays propagating within said laser rod, and minimizing the size of said taper so as to maximize the fractional volume in said laser rod that is accessible to an extracting laser beam.